Data Collection and Global Data Fusion in C4ISR in the Czech Armed Forces

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INTRODUCTION

The beginning of the research of control and information systems started in the deep past. At first the systems were based on simple mechanic and electro mechanic utilities, able to control single element, but during the development of new technologies the systems became much more difficult. These systems allowed to control more elements and their command posts, support operators and their decide processes and also included needed communication infrastructure.

From original purpose to control single weapons systems research gets to building of whole complexes, which provides control of units command, fire coordination, data gathering and so on.

During complex system realizations there is one serious problem, which is not as resoluble by technical tool, as system's intelligence. This problem is in processing a big number of data, fusing its content to explicit context, interpretable by automated systems. This is the main problem of systems for fire control.

HISTORY

Original fire control systems operated with very simple data and knowledge model of battlefield situation. Simple example: target was engaged by element, if the expected path of the target leads directly to the element. The very intelligence of fire elements use, the moment and the method of its use remain on commander's decision.

In near history, about 1989, the Czech Air Forces were using legacy systems K1M and SENĚŽ ME with implemented algorithms of fire control. The algorithms were quite as simple as it has been described in the previous part. The Czech republic stopped using of these systems in 1998 because they were not able to be adapted to work in new environment, in cooperation with new systems and they were not be able to implement new algorithms for control of ground based air defense systems. Despite these facts, when we started development of the new systems (SHARC, LADIC), we were using simple algorithms based on legacy systems.

The gathering information about target position was also taken in very primitive way and the interpretation depended on operator's skills and intelligence. By growing abilities of data gathering systems and data automatic processing the information data capacity get past the system operators abilities. For example for fire control system there is a data gathering process from various sources such as RADAR

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rangefinders, altimerts, 3D systems, passive sensors, intelligence systems, etc… Interpretation and processing of this data to superior information is relatively difficult and multilevel operation.

If the operator has to gauge characteristics of only a few objects, his activity can be effective. To gauge the whole battlefield situation when there is a lot of targets is impossible. The characteristics are much more difficult, if the gauge of object in history is needed for gauge its current behavior.

Because in these days the operator is still only a human, we have had to find out a solution how to make the decision easier. It is needed to get important information from the big packet of data – in and create very simple air picture. After that, the operator is able to work with the air picture.

Another problem of fire control is to get together this information with information about fire elements, which are also in various forms and include beside exact information also inexplicit information such as operators skills, and so on. After input of all this information to common picture of the battlefield it is possible to make the optimal decision.

The information about fire units is in very different form – statement of maximum range of missile, maximum range of reconnaissance but also level of operator's skill or influence of weather to fire result. This information isn't exact but it is indefinite and mostly it is expressed with measure of persuasion. Common system is not able to work with measure of persuasion by the common math apparatus but it is needed to use for example expert system, fuzzy logic system or neural network.

In scope of development of air defense command and control systems for Czech armed forces, systems SHARC and LADIC, there were improved a technology of data fusion to extract relevant information for fire control operators decide process. Used technologies issues from known and published algorithms and procedures and also from its new implementations and from new novel mechanisms.

HOW TO ACHIEVE THE RIGHT EFFECT?

For the optimal process of command and control we have to see the battlefield like in a single piece. It has its own history, its own actual status and its own foreseeable future. Therefore we can't control the fire by the way, how the battlefield is looking now, but we have to take its history and requisite future into our consideration.

The whole process starts with collection of information about air picture. The information contains number of targets in the air, their position, identification (if it is available) and other information that is detectable by the primary and secondary detectors. This information includes false alerts too, that it is needed to get away.

In this moment processing of air picture is starting. Next parameters, velocity, alpha code, unified trajectory, are added here. At the same time the false alerts are filtered. At last we have "Recognized air picture (RAP)" but it isn't the last operation. At the total end we have to join our picture to the information delivered from intelligence service. This is our perfect and exact air picture.

Next task is to collect information about our fire units that we are able to receive from their reports about their status and abilities to fight that they transmit to us. There is something like tertiary processing, where we are able to capture information about the time, when the unit will be able to fight, about the possibility to move and we are able to influence the ability to kill target in the air. This is very important relation. There aren't only our air defence fire units in the battlefield but there are other friend units and foe units too. We have to get all this information together to create total picture of the ground situation.

If we have "Recognized air picture" and "picture of the ground situation", we will create "Common operation picture (COP)" at the end. COP is complete description of the battlefield and it is data reality of

the real situation. This description is more or less exact; it depends on the precision of data-in and precision of their processing.

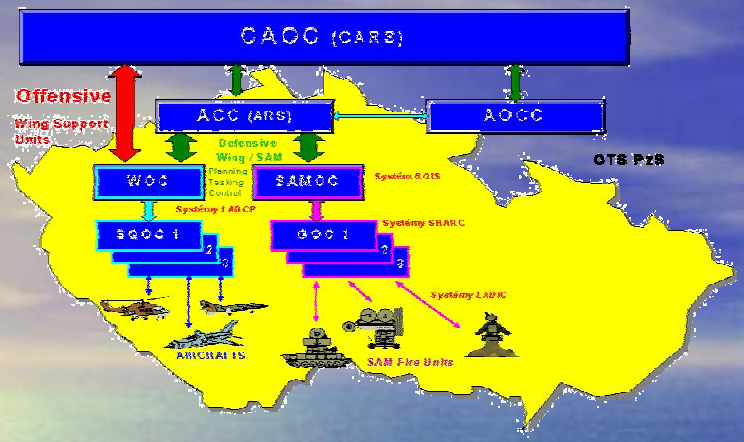
It seems to be all in the area of data fusion in C4ISR systems but the opposite is right. If we have complete COP, next task will be making a final decision for own fire unit. By this complicated process we take the COP and our experience from previous battles into our consideration. The operator usually makes the decision by heart but we have to put his experience on software and hardware. So we should create sophisticated knowledge base to save experience and it is needed to create some algorithms to get information out. In this case we can use previous experience to make decision automatically. This process is just the most difficult data fusion process in command and control systems. Nowadays we do our best to find the best solution of this problem for systems SHARC and LADIC. If we solve out this process, our systems will learn to make decision based on previous experience. By this way we have come to the last problem data fusion in C4ISR systems.

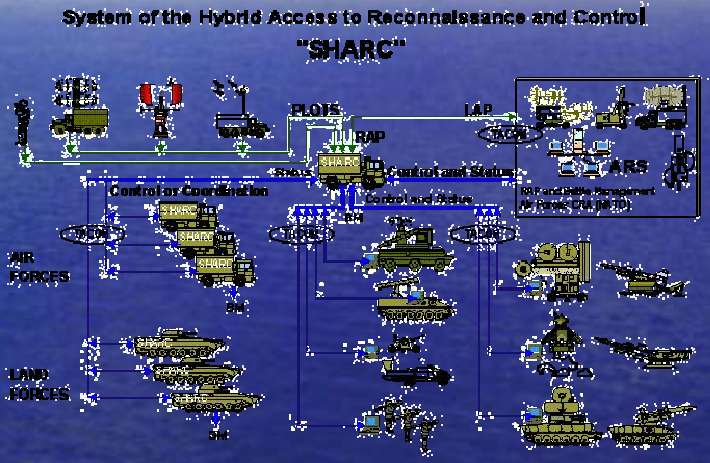
As soon as we create decision, we will watch how the battlefield behaves. We still collect data about battlefield behavior and we have to extract the most important things from everything. The fusion with previous experience is following now and it is very difficult and complicated process, of course. Full version of the process has never been included in our systems.

CONCLUSION

Data fusion in C4ISR systems is very difficult problem, which is running at several levels. We could say that data fusion is getting more difficult at every layer. Data fusion is at the lower layers simple math problem but at higher layers we can't solve needed algorithms by direct math apparatus. Here is a place for neural and experts systems.

Battlefield situation data gathering methods and data fusion methods that are presented in contribution are used in C4ISR systems at the Czech armed forces, especially at Czech air forces. Presented advances and methods issues from work and publications on systems SHARC and LADIC in the Research and Development Institute of Air Force and Air Defense Prague and the Military academy in Brno between 1998 - 2003.





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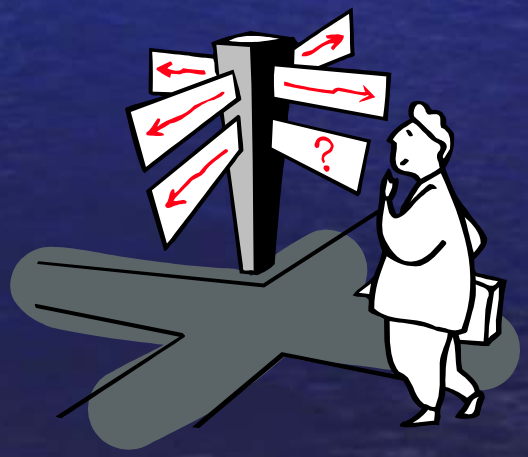
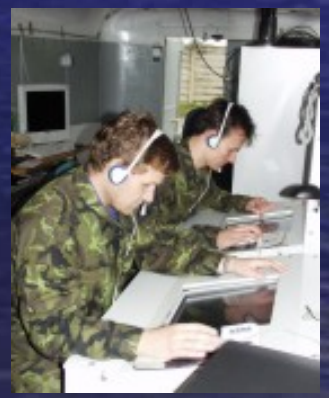


Introduction

- The first systems - based on simple mechanic and electro mechanic utilities
- New technologies - the systems became much more difficult / complex
- Problem - processing a big number of data
- Fusing data content to explicit context
- Requirement – to build smart systems



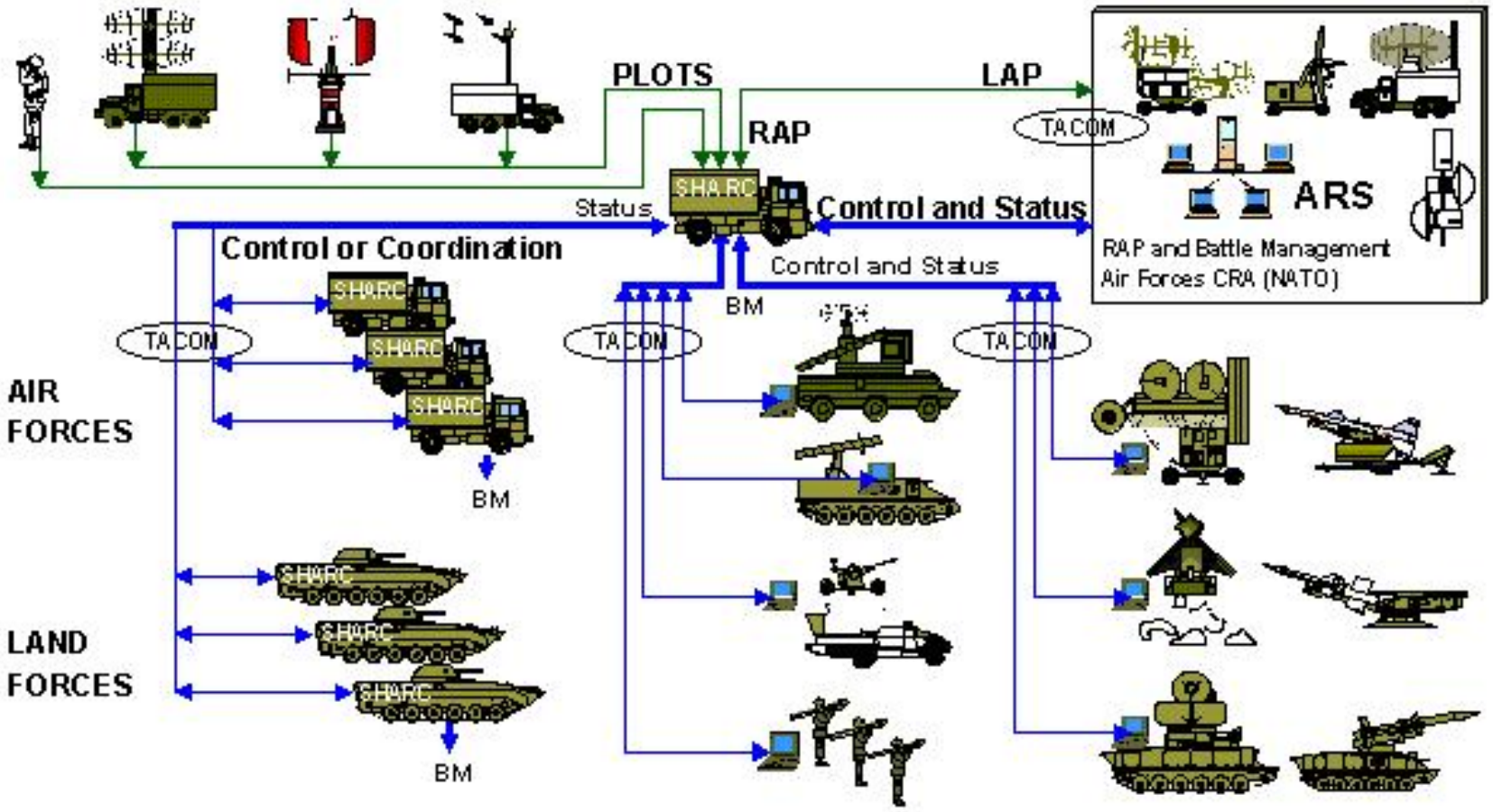
History

- The first fire control systems operated with very simple data and knowledge model
- Intelligence remain on commander's decision
- Czech Air Forces were using legacy systems K1M and SENĚŽ ME
- They were not able to be adapted

New systems

- The Czech Republic stopped use of legacy systems in 1998
  - they were not able to be adapted to work in new environment in cooperation with new systems
  - they were not be able to implement new algorithms for control of ground based air defense systems
- SHARC – GOC level
- LADIC – FU level
- New systems – we had to develop new algorithms for control of the fire unit based on new technologies

System of the Hybrid Access to Reconnaissance and Control "SHARC"



Gathering information (RAP)

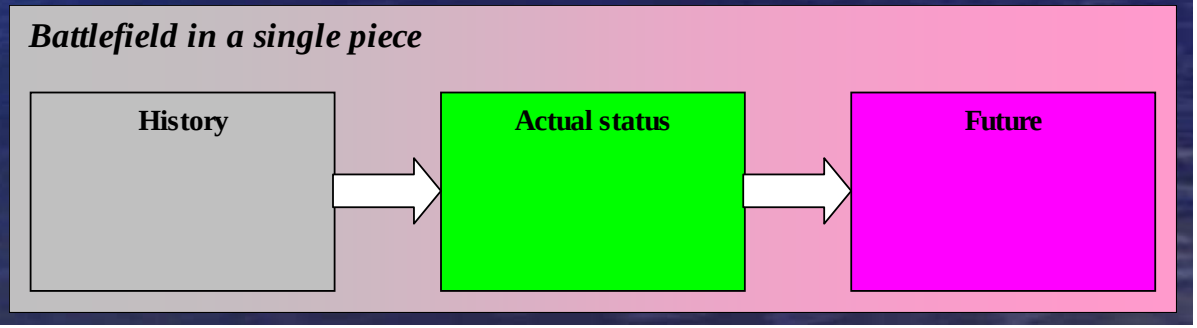
- In history - primitive way and the interpretation depended on operator
- Now, we have various sources and a lot of data
- Interpretation and processing of this data to superior information is relatively difficult and multilevel operation
- We are needed create very simple RAP

Gathering information (FU)

- The information about fire units are in very different forms:
  - Statement of maximum range of missile
  - Maximum range of reconnaissance
  - Level of operator's skill
  - Influence of weather to fire result
- Some of the information are not exact
- It is necessary to use for example expert systems, fuzzy logic systems or neural networks.

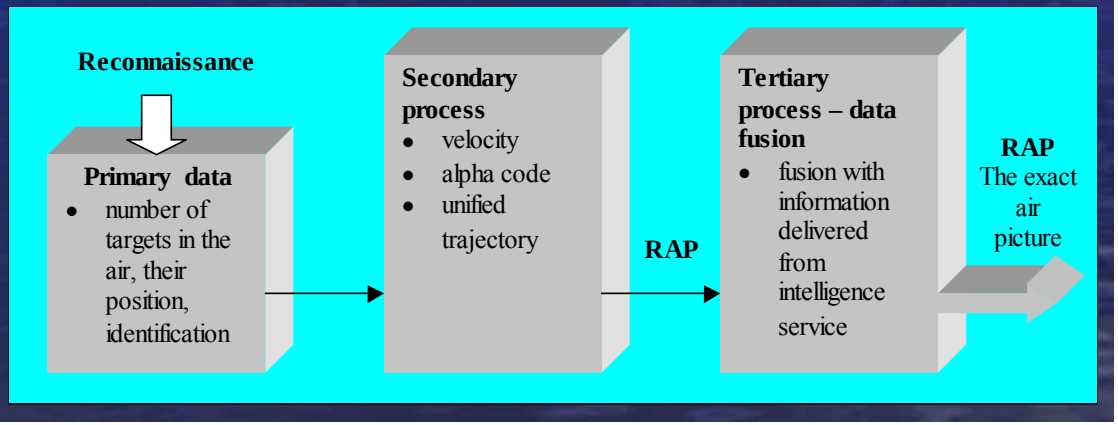
The new view to battlefield

- For the optimal process of command and control we have to see the battlefield like in a single piece.
- It has its own history, its own actual status and its own foreseeable future.
- Therefore we can't control the fire by the way, how the battlefield is looking now, but we have to take its history and requisite future into our consideration.



Creating RAP

- The whole process starts by collection of raw data.
- First - number of targets in the air, their positions, identification (if it is available) and other data that is detectable by the primary and secondary detectors / radars (partially preprocessed)
- Second - processing (filtering, selecting …) to create useful information for next step
- Third - combine information from second step of the processing and the information delivered from intelligence service to RAP

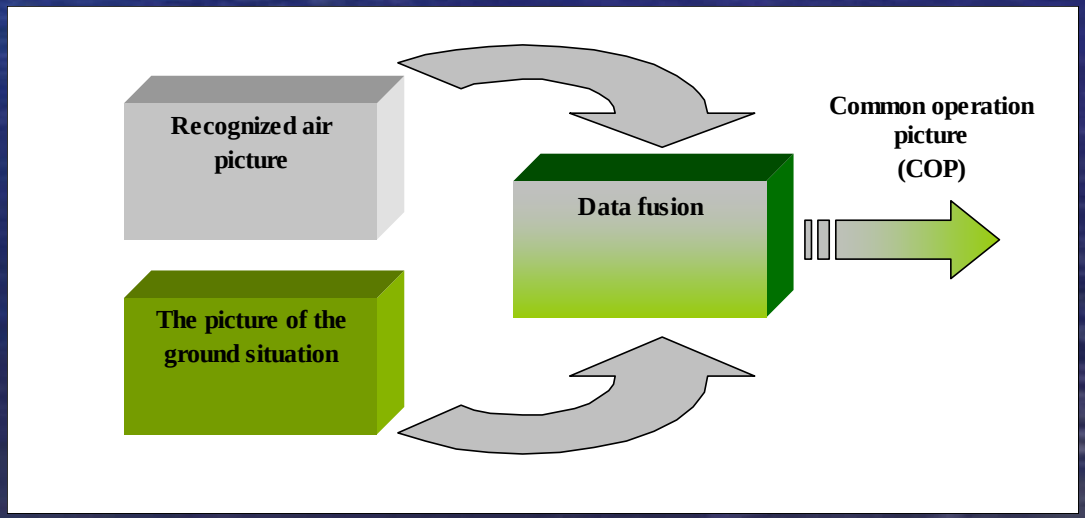


Other information

- Next task - collection information about our own fire units.
- Similar to tertiary processing
  - information about the ability of units
  - about the possibility to move
  - Information fusion will help us to precise the ability of the fire units actions
- Collection of other data
  - our air defense fire units
  - other friend units
  - foe units

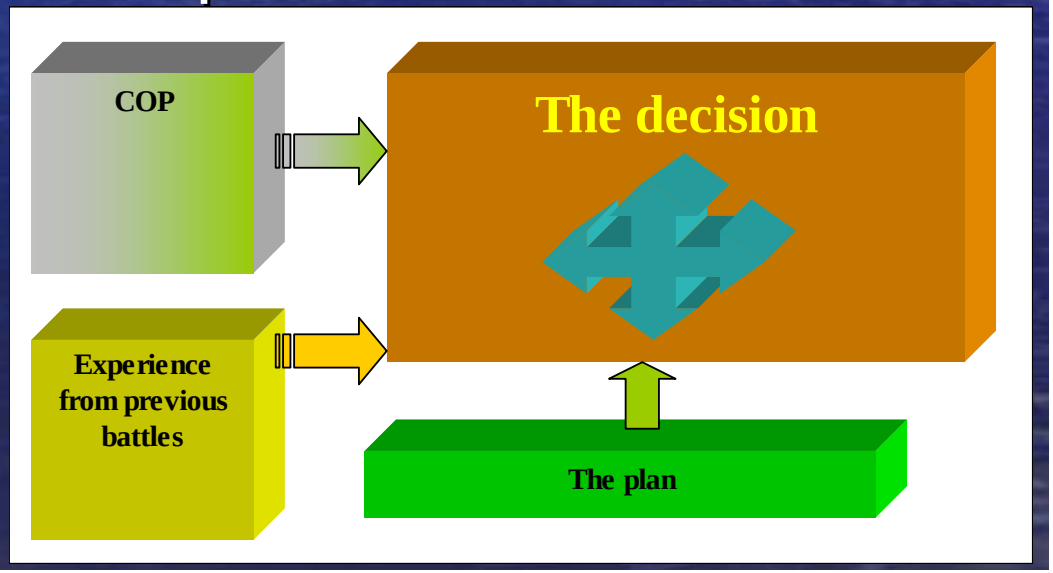
Common operation picture (COP)

- COP is complete description of the battlefield and it is data reality of the real situation.
- This description is more less exact; it depends on the precision of data-in and precision of their processing / fusing.



Decision

- It seems to be all in the area of data fusion in C4ISR systems but the opposite is right.
- Next task - making a final decision for own fire units.
- By this complicated process we take the COP and our experience from previous battles into our consideration.



Feedback

- We have to watch behavior of the battlefield
- Permanently collection of the data about battlefield
- Extract the most important information from all sources
- Fusion with previous knowledge / behavior
- Difficult and complicated process

Conclusion

- Information fusion in C4ISR systems is complex problem to have be solved
- Fusion is using at several levels
- Information fusion is getting more difficult at every layer
- Lower layers - simple math problem
- Higher layers - neural and experts systems

Questions

Thank you for your attention.

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